Space Weather Technical Forecast

Issued on Monday, 22 May 2023 at 13:16 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further R1/R2 radio blackouts likely. G1 Minor/G2 Moderate storms likely day 2 (23 May). Active fluence likely by end of day 4 (25 May).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with peak flare of M2.6 at 21/1604UTC from AR3311, a complex region in the northeast quadrant, which still contains a delta spot. AR3305 is now rotating over the west limb, and was the source of a C9.8 flare at 21/2213. AR3310 is a large region in the southeast, however this appears generally stable with little activity observed. The other regions are all smaller and simple to give at total of seven sunspot regions on the disc. No Earth-directed CMEs have been observed in the past 24 hours.

Solar Wind / Geomagnetic Activity: The solar wind, as measured at L1 was around 450 km/s to start. This then gradually rose from 21/1300 UTC to reach around 600 km/s early on the 22 May before slowly declining to current levels around 550 km/s. This likely due to a combination of a weak CME arrival, perhaps from 17 May, and a SSB crossing into slightly elevated winds from an unknown source. Density was below average, but rose around 21/1430 to be around average. The total magnetic field strength Bt, was weak at first, but rose to from 21/1300 UTC to peak at 21/1510 UTC at 13nT. The north-south component, Bz, was mainly weakly negative, but reached a minimum value of -10nT at around 21/1940 UTC. Phi angle was highly variable, initially negative (towards the Sun) but rotated to be increasingly positive (away from the Sun) from 21/2200 UTC. Geomagnetic activity was initially Quiet to Unsettled, but rose to give G2/Moderate storms (Kp6) 1800-2400 UTC before declining back to Quiet levels.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as measured at GOES16 has remained at background levels throughout. High energy electron flux (greater than 2MeV), as measured at GOES16 was mainly at background levels, but briefly rose to from 21/1400 UTC to peak at High, reaching 1080 pfu at 21/1455 UTC before falling back to background levels. The 24-hour integrated fluence has been well below Active levels. At 22/0000UTC, 1.49e7 integrated pfu was recorded.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be mainly Moderate, with a slight chance of High activity, due to either multiple M-class flares, or the slight chance of X-class flares. The main risk region is AR3311 in the northeast quadrant, which has produced multiple M-class flares in the last 72 hours.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs currently forecast.

Current elevated solar winds are expected to gradually ease during day 1 (22 May) before the onset of a further enhancement from the arrival of the fast wind from CH06/-. This is expected early on day 2 (23 May), with solar winds potentially peaking around 600 km/s, and only gradually easing later in the period. Geomagnetic conditions initially to Quiet to Unsettled with

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chance of Active. Fast wind arrival most likely early day 2 (23 May) is then expected to give Active to G1 Minor Storm intervals, with a chance of isolated G2 Moderate storms. These conditions easing through day 3 and day 4 (24-25 May) to be mainly Quiet to Unsettled with Active intervals possible.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to be at background, but carries a chance of rising in response to any large flares that occur, with a slight chance of reaching the S1/Minor Storm threshold. High energy electron flux (greater than 2MeV) will likely rise, erratically at first, but more persistently day 3 and 4 (24 and 25 May). This will give a likelihood of reaching the Active threshold by the end of day 4 (25 May).

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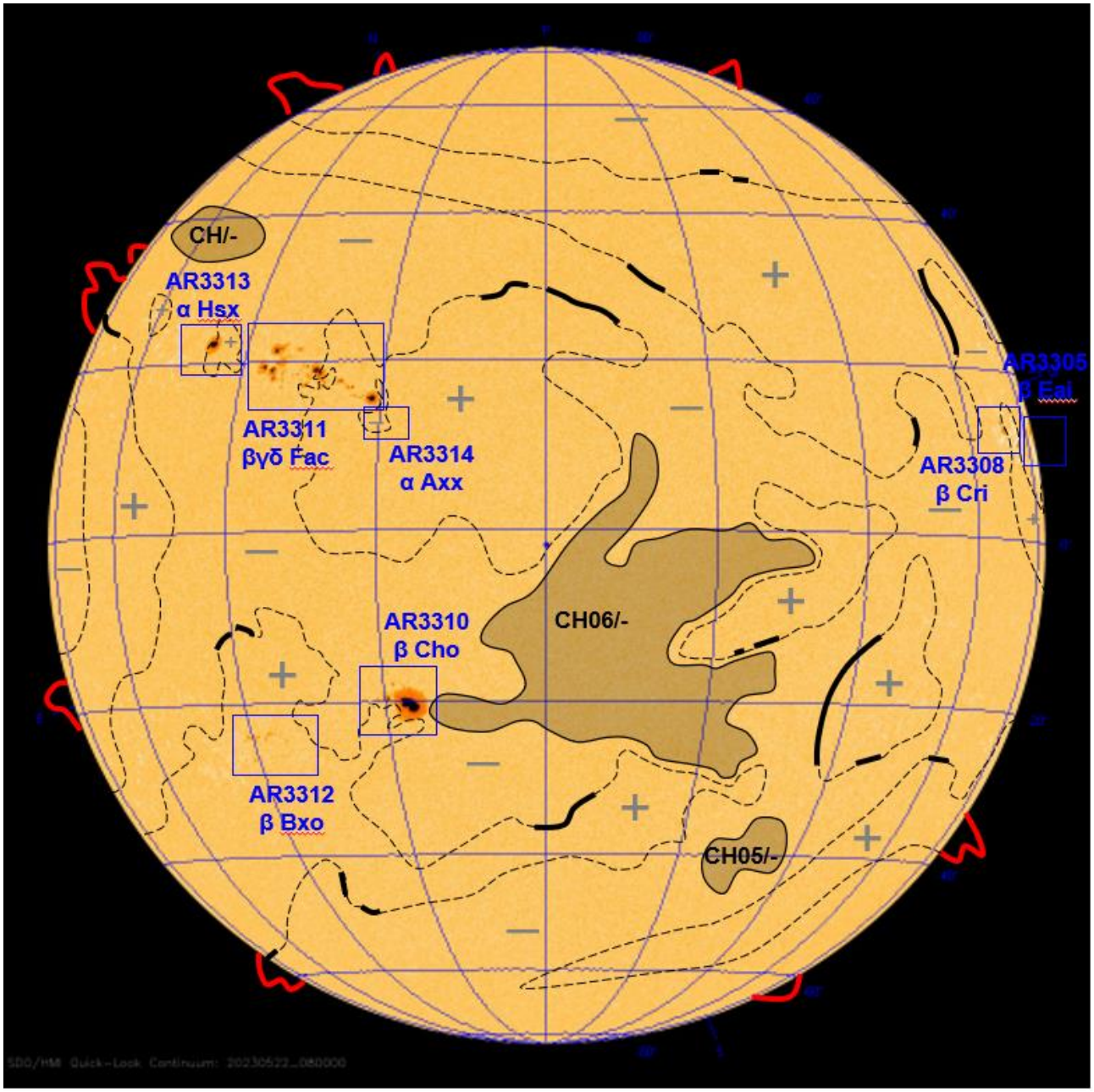
Figure 1. Solar Analysis Valid 22/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

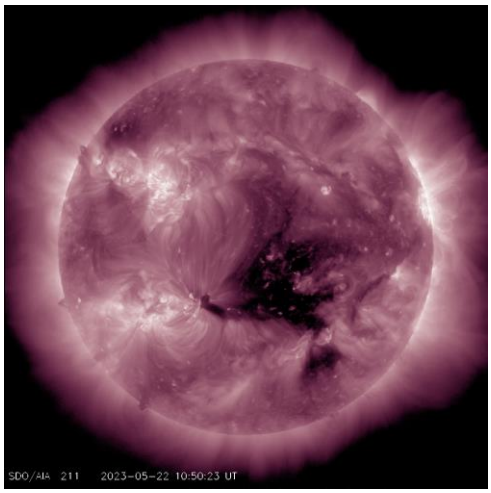
There are currently no Earth-directed CMEs forecast.

Solar winds are currently enhanced due to the likely recent arrival of a weak and glancing CME which left the Sun on 17 May, potentially embedded within a region of slightly elevated solar winds associated with a SSB (solar sector boundary) crossing. These elevated winds are likely to gradually ease during the remainder of day 1 (22 May) before rising again during day 2 (23 May) due to the expected arrival of the fast wind associated with CH06/-. Peak speeds of around 600 km/s look possible. The fast winds are expected to persist into day 3, slowly easing day 4 (24-25 May).

Geomagnetic activity currently Quite to Unsettled. CH06 fast wind arrival likely early day 2 (22-23 May) is then expected to give Active to G1 Minor Storm intervals, with a chance of isolated G2 Moderate storms. These conditions easing through day 3 and day 4 (24-25 May) to be mainly Quiet to Unsettled with Active intervals possible.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	30	60	30	1
Strong	G3	No	1	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: Latest SDO/AIA 211 imagery showing Coronal Hole CH06/- as dark region center disk.



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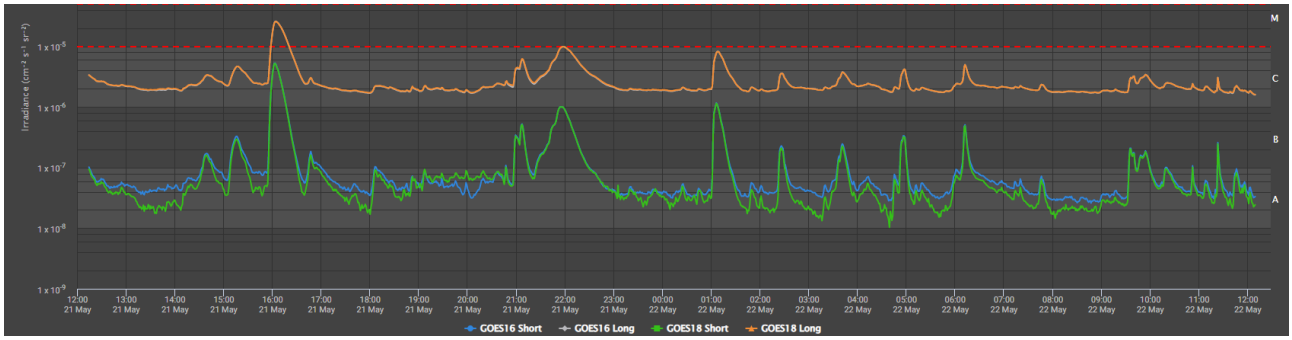
Radio Blackouts - X-Ray Flares:

Complex region AR3311 in the northeast appears to be stabilising to a degree, but it remains longitudinally wide and comprised of a number of smaller umbral areas, with a small delta amongst its intermediate spots. This region was the source of the two larger M-flares on 20 May as well as the more recent M2.6 at 21/1604UTC, and continues to present the main risk of further M-flares with a slight chance of X-class.

Region AR3305 is located on the northwest limb, and is soon to rotate off the visible disc, but also maintains a chance of M-class flare activity into the start of the period. Another large region, AR3310, is dominated by a single large and mature spot and is expected to remain stable until we see any further development. The other four spots on the disc are much smaller or generally stable, and less likely to give notable flare activity.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	20	20	20	20

Figure 3: latest 24hr GOES-16 X-Ray flux



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16 has remained at background levels throughout and is expected to remain as such throughout the period. There is the potential for some enhancement in the near term due to any flare activity from the sunspots that are currently rotating over the western horizon or perhaps in response to the recently observed large far sided halo CME. Increasingly the main risk transferring to any larger flares from the complex region AR3311 as it rotates westward into the period. As such a slight risk is maintained throughout.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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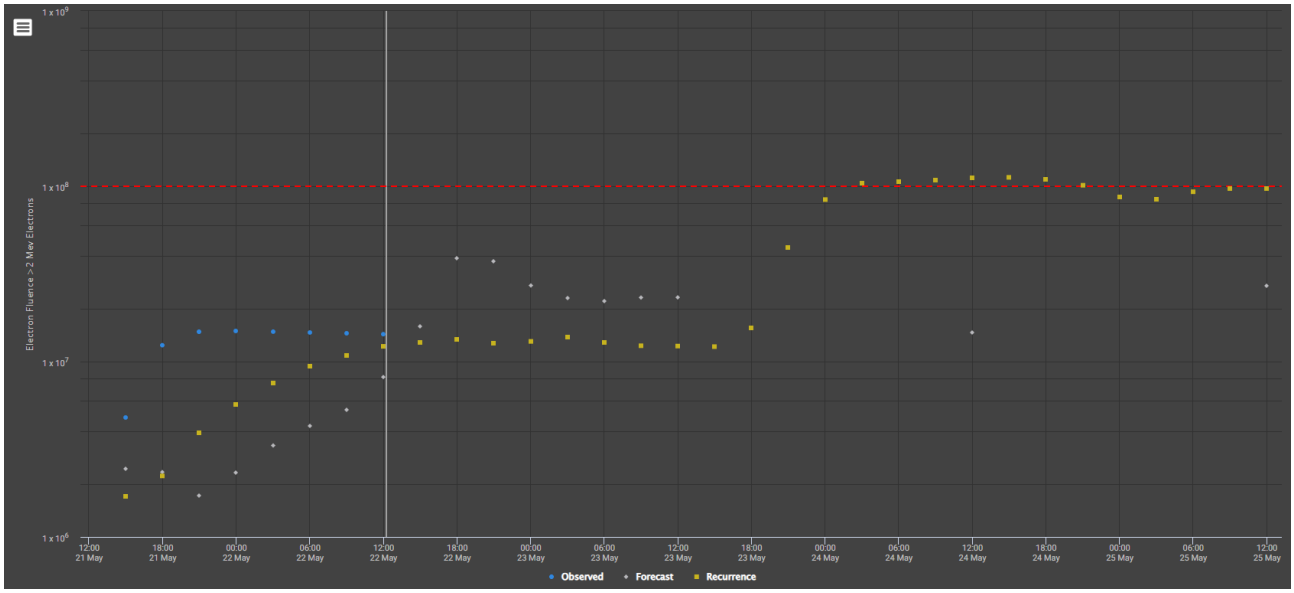
High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) as observed at GOES-16 is currently at background, likely due to increased solar wind pressure constraining the outer Van Allen Belt inside of GEO as a consequence of the weak CME and slightly elevated solar winds. Recent enhancement have likely increased electron populations however, and as solar winds ease day 1 (22 May) Moderate to High flux possible for a time. The onset of the fast wind of CH06 is likely to further constrain the belt inside GEO however giving a further period of mainly Background flux into day 2 and day 3 (23-24 May). Flux levels are then expected to rise again as any geospace disturbance eases, reaching Moderate to High, likely persistently High, by day 4 (25 May).

The associated 24 hour electron fluence is expected to remain below the Active threshold until perhaps day 3, but more likely day 4. This is supported by REFM which is currently giving reasonable guidance.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	5	10	30	60
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 4: Latest MOSWOC REFM model output



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